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FINAL REPORT

RECOMMENDATIONS FOR ECOLOGICALLY BASED LEAD REMEDIAL GOALS

NATIONAL LEAD INDUSTRIES
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Introduction

Based upon concerns for potential threats to ecological receptors the U.S. Environmental Protection Agency (EPA) Region II requested the assistance of the Environmental Response Team (ERT) at the National Lead Industries Site (NL) in Pedricktown, New Jersey. The issues investigated within this study included evaluation of the potential ecological risks of lead contamination at the site, and assistance with the development of ecologically based risk management options. The present document summarizes the results of the environmental assessment studies conducted and presents the recommendations based upon these studies.

The strategy employed to meet the study objectives was to conduct a series of field evaluations of lead bioavailability through toxicity testing and contaminant accumulation studies. The results of the toxicity tests were interpreted directly while the data from the accumulation studies was used to assess Pb exposure and the associated ecological risk to food chain receptors, based upon models. The results of the field investigations and the results of the ecological risk models were then incorporated into recommendations for remedial objectives. The results of the field studies can be found in the U.S. EPA-ERT report Field Ecological Assessment National Lead Site, June 1993 (Field Assessment). The results of the ecological risk modeling can be found in the U.S. EPA - ERT report National Lead Industries Pedricktown, New Jersey Ecological Risk Assessment, June 1993 (Risk Assessment).

This report integrates the potential ecological risk contributed by lead at the National Lead Site, with field observations concerning the habitats present, habitat utilization, potential impacts to habitats due to remedial efforts and evaluation of ecological risk reduction given assumed remedial alternatives. The uncertainties and modeling assumptions were considered in drawing conclusions.

The conclusions and recommendations of this report are site specific and should be used only for the management of risks at the National Lead Site, Pedricktown, NJ. The selection of the remedial alternative, for the National Lead Site, is anticipated to incorporate the conclusions and recommendations of this study, as well as other factors. It is also important to recognize that direct action to eliminate all ecological risk may not be feasible or warranted, however, the residual risk which exists after site remediation must be considered.

Field Ecological Assessment

A field ecological assessment was conducted at the National Lead Site. This study utilized a 28 day *in-situ* earthworm toxicity and bioaccumulation test; collection and analysis of small mammals from three levels of Pb exposure; collection and analysis of frogs from both the East and West Streams; solid-phase toxicity tests for Pb contaminated sediments; and field evaluation of the habitats present at and around the site.

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This field study was designed to generate data which could be used directly to evaluate current threats to environmental receptors and to provide the data necessary to model the potential threats to environmental receptors which could not be directly evaluated.

The results of the Field Ecological Assessment can be summarized as follows:

1) Results of a fourteen day solid phase toxicity test using larvae of the midge *Chironomus tentans* indicated that test mortality did occur but was associated with loss of test water alkalinity and subsequent pH drops in the overlying water. However, mortality within the tests must be assumed to be a function of pH reduction, as well as the potential increased lead exposure, as a result of changes in lead availability with depressed water column pH. Therefore, the potential for alteration (depression) of surface water pH, must be considered in conjunction with the potential threat of lead in the site aquatic habitats.

2) Evaluation of chronic effects within the fourteen day solid phase toxicity tests indicates that significant reduction in growth occurred at a sediment concentration of 1100 mg/kg dry weight. However, 1100 mg/kg can not be assumed to be the lowest observable adverse effects level (LOAEL) as the lower concentrations tests had mortality (believed as a result of confound factors).

3) Green frogs (*Rana clamitans*) had a mean lead tissue concentration of 9 mg/kg wet weight in the West Stream (range 1.4 - 23 mg/kg wet weight). The highest concentrations were noted at locations within the West Stream which were closest to the NL facility. The mean tissue level in the East Stream was lower (6 mg/kg).

4) Earthworm (*Eisenia foetida*) exposed to a range of site soil Pb contaminations (120 to 6900 mg/kg dry weight) accumulated a maximum of 170 mg/kg wet weight over a 28-day exposure period. Analysis of the accumulation study results indicate that increased Pb and organic content of the soil is associated with increased accumulation of Pb.

5) Bioaccumulation factors (BAF, Pb in tissue divided by Pb in soil) decreased as soil Pb contamination increased, following a negative exponential function. This relationship has been observed in other studies. The change in accumulation may be a result of aversion to feeding, chronic toxicological responses, or altered availability of the Pb at higher concentration levels.

6) It can not be concluded that the Pb levels found in the earthworms were directly detrimental to the earthworms. Earthworms in all chambers did experience significant weight loss which was weakly correlated with Pb concentrations (r=0.6). Observed mortality was noted in several chambers but could not be attributed to Pb content or other measured parameters.

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7) White-footed mice (*Peromyscus leucopus*) is the most abundant small mammal on site. There was significantly greater accumulation of Pb in mice collected from Area III (Pb range 438 - 4930 median 2031, mean 2286) than in area I (Pb range 148 - 4177 median 1650, mean 1627). Area II Pb accumulation was not statistically different from either area I or Area III. Mice collected from Area I contained a mean Pb tissue concentration of 1.60 +/- 1.10 (1 SD) mg/kg wet weight, Area II contained 3.10 +/- 3.02 mg/kg and Area III contained 4.77 +/- 3.50 mg/kg.

8) The forested wetlands in the vicinity of Grid IA and immediately north of Grid III (Area III) represent high quality habitat for breeding forest birds and resident mammals, based upon the professional judgment of the field investigators.

9) A total of 41 species of birds, 12 mammalian species, 6 reptiles and 5 amphibians were observed at the site. No attempt was made to inventory fish species utilizing the East or West Streams.

The conclusions which can be directly drawn from the Field Ecological Assessments include:

1) Sediment Pb levels of approximately 1100 mg/kg pose a demonstratable ecological threat as evidenced by the chronic toxicological response of *C. tentans*, a species which is generally accepted as metals tolerant. Since a LOAEL (low observable adverse effects concentration) could not be obtained from the toxicity test results, but the test results were chronic effects, a safety factor of 2 is believed appropriate for estimation of a LOAEL for direct sediment toxicity. Therefore, it is recommended to a clean-up objective of 500 mg/kg be applied to the sediments of East and West Streams.

Ecological Risk Assessment

Utilizing the site specific Pb accumulation data generated from the study described above (Field Ecological Assessment), a food chain model was used to evaluate the potential Pb exposure to selected ecological receptors. The selection of ecological receptors was based upon receptor sensitivity to Pb and position in the food chain. The exposure scenarios used in the exposure model and the risk calculations conducted are viewed as being representative of key food chain pathways and reasonable worst case ecological risk, not solely risk to the assessment endpoint organism (the receptor to which the model was applied).

Exposure assessment and risk calculations were conducted for: robin, woodcock, great blue heron, red-tailed hawk, long-eared owl, red fox and mink. The hazard quotient (HQ) method was used to calculate the risk posed to receptors based upon the exposure assessment. The earthworm accumulation data from the Field Ecological Assessment was used as being representative of the forage base for the robin and the woodcock. The frog accumulation data was used to represent the forage for the great blue heron,

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while the white-footed mice data was used to represent the forage base of the red tailed hawk, long-eared owl and the red fox. For the mink exposure both the frog and mice data were used to represent the forage base.

Additional details of the exposure model and the assumptions made within the exposure model, as well as details regarding the HQ calculations, can be found in the Ecological Risk Assessment (June 1993) document.

Conclusions of the Ecological Risk Assessment

1) Potential risk calculations (using the HQ method) were made for the robin (*Turdus migratorius*), american woodcock (*Philohela minor*), great blue heron (*Ardea herodias*), Red-tailed hawk (*Buteo jamaicensis*), long-eared owl (*Asio otus*), red fox (*Vulpes vulpes*), and mink (*Mustela vison*). The risk calculation utilized the results from the field ecological assessment to the greatest extent possible.

2) Results of the risk calculations suggest that potential risk (HQ >1 but less than 10) exists at the site for the red fox at soil concentrations above approximately 1000 mg/kg wet weight or approximately 500 mg/kg dry weight. Potential risk (HQ >1 but less than 10) to mink was calculated at the lowest soil/sediment concentrations evaluated approximately 500 mg/kg Pb wet weight. For the great blue heron a HQ = 1 was calculated only for the highest sediment concentration evaluated, sediments over 2000 mg/kg wet weight. A HQ of less than 1 was found for even the highest soil concentration evaluated for both the red-tailed hawk and the long eared owl. For the robin a potential threat (HQ >1 but less than 10) was calculated for all soil concentration evaluated. A HQ of 8.41 was calculated for soil concentration of greater than 1000 mg/kg wet weight. For woodcock HQ calculations exceeded 10 for all soil concentrations evaluated, the lowest soil level being <500 mg/kg wet weight.

3) The magnitude of the hazard quotient for Pb threat is strongly influenced by the incidental ingestion of soil, and the assumption of 100% availability of administered dose, assumed in both the literature based LOAELs and the modeled dosing for the site.

Conclusions from the Ecological Risk Assessment

1) Lead exposure modeling and risk calculations suggest minimal risk to avian receptors but a potential treat to other semi-aquatic predators at sediment concentrations as low as approximately 200 mg/kg dry weight. Considering the conservative assumptions and uncertainties associated with the exposure model which resulted in a calculated potential threat of over 10 at approximately 200 mg/kg; that most of the exposure models suggested less risk (HQ >1 but less than 10) at higher soil/sediment concentrations, the value of 200 mg Pb/kg is viewed as conservative.

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2) At a soil/sediment concentration of 500 mg Pb/kg the exposure/risk scenarios suggest only a potential for risk, with some scenarios having a HQ>1 and some not having a HQ >1. Only in the case of the woodcock does the HQ greatly exceed 1 (as noted above).

3) At approximately 1000 mg Pb/kg only the HQ for the great blue heron, long-eared owl and red-tailed hawk do not exceed 1. This suggests that at soil/sediment Pb concentrations of approximately 1000 mg Pb/kg ecological threats may be occurring.

Overall Recommendations

Sediment Clean-up Goals

Results of the sediment toxicity tests, as discussed above suggest that a clean-up goal of 500 mg Pb/kg dry weight would be appropriate. In addition the Pb exposure modeling and risk calculations suggest minimal risk to avian receptors but a potential treat to other semi-aquatic predators at sediment concentrations as low as approximately 200 mg/kg dry weight. Considering the conservative assumptions of the exposure model which resulted in a calculated threat (HQ >10) and the direct toxicity data, it is recommended that a clean-up goal of 500 mg Pb/kg dry weight be applied to sediments. In meeting this goal, the potential for redistribution of contamination during and post-remediation should be considered to avoid the reoccurrence of Pb concentrations above this clean-up goal.

Wetland and Associated Terrestrial Areas

Based upon the exposure assessment and the HQ calculations the potential for ecological risk (HQ >1 but less than 10) exists for red fox, mink, and robin at soil Pb concentrations of approximately 500 mg/kg dry weight. At the same soil concentration the HQ for the woodcock is calculated to be over 20. Considering the conservative nature of the assumptions used in the exposure model, the uncertainty associated with the literature toxicological data and the potential for expanded impacts to existing habitat as a result of aggressive site remediation, a clean-up goal of 500 mg Pb/kg dry weight is recommended.

It must be recognized that these recommendations, if implemented, do not represent fully "protective" Pb soil/sediment concentrations.

Accumulated levels of Pb in the terrestrial species collected from the site, and those exposed to the site soils, did not appear to accumulate to levels which would result in direct adverse effects. However, the toxicity testing results and the risk calculations, while conservative, indicate that there is a threat which could exist below 500 mg/kg Pb in soil to the selected indicator species, robin, woodcock, red fox and mink at the site.

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The risk assessment suggests that an ecological threat may exist at soil/sediment concentrations below 500 mg Pb/kg, however the environmental benefits realized by the removal of these contaminated media versus the destructive nature of aggressive remedial actions suggests that a clean-up goal below 500 mg Pb/kg may not be appropriate.

Other Recommendations

Since residual risks will likely be left at the site post-remediation it is important that an ecological monitoring plan be developed. This monitoring plan should be developed and reviewed through the Regional Biological Technical Assistance Group (BTAG). It may be advantageous to solicit the input of the BTAG in identifying residual environmental concerns; this could provide direction in developing this monitoring plan.

Also, it may be in the best interest of overall site management to document the actual residual Pb levels after remediation. This would allow a more accurate evaluation of the residual threat at the site post-remediation. This information could be included as part of the monitoring plan suggested above.

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